Resistance inductors for potato late blight management in Peru

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Abstract

We studied the effectiveness and efficiency of resistance inductors (RIs) for potato late blight LB control in the Peruvian highlands. Plantlets of susceptible cv. Yungay previously sprayed with one of the following commercial RIs: PKplus®, Manvert Biolet®, Miconic ® and Manvert Silikon®, were inoculated with *Phytophthora infestans* isolate POX067 under laboratory and greenhouse conditions. Low LB severity values on the foliage were obtained with PKplus® and Manvert Biolet®, which were selected for field experiments using four potato cultivars with different levels of susceptibility in three growing areas in the Pasco department during the rainy season. Treatments included PKplus®, Manvert Biolet®, propineb (alone or alternated); a decision support system (DSS, using commercial systemic and/or contact fungicides); and a plot with not fungicides. The most effective and efficient treatments were PKplus® and propineb alone, PKplus® alternated with propineb and the DSS in susceptible cultivars; PKplus® and Manvert Biolet® alternated with propineb, and propineb alone in a moderately resistant cultivar; and propineb alone in a resistant cultivar. Since PKplus® have very low environmental impact quotients, these results showed that it is possible to control potato LB in a profitable and environmentally-friendly manner, even in susceptible cultivars during the rainy season.

Keywords: *Phytophthora infestans*, fungicides, economic analysis, environmental impact.

Introduction

The main constraint for potato production is late blight (LB), a disease caused by the oomycete *Phytophthora infestan*s (Mont.) de Bary. Annually, it causes losses of nearly 10 billion euros (Haverkort et al., 2009). In some places, such as the Andes, LB management is difficult to manage due to climatic conditions and continuous potato production (Kromann et al., 2008). The use of fungicides is the most common method to manage LB, however, it has a negative impact on peoples' health and environment (Haverkort et al., 2009). An alternative method to manage LB is the use of resistance inductors (RIs) that stimulate the self-defense of plants trough different mechanisms, like the activation of defense genes of salicylic acid and jasmonic acid/ethylene pathway (Jones and Dangl, 2006).

In this study, we determined the efficacy of four commercial RIs under laboratory and greenhouse conditions in a susceptible potato cultivar, selected the best two and then tested them under field conditions in four potato cultivars with different levels of susceptibility.

Methods

Four RIs (PKplus®, Manvert Biolet®, Miconic® and Manvert Silikon®, provided by the Hortus company) and three control treatments (two contact fungicides, -mancozeb and propineb-, and water) were tested in laboratory (detached leaf) and greenhouse (whole plants) assays at the International Potato Center in Lima, Peru. Each RIs was sprayed on plants of susceptible cv. Yungay. For the detached leaf assay, inoculation with *Phytophthora infestans* isolate POX067 was carried out at 1, 2, 3, 7 and 15 days after spraying the RIs, while in the whole plants assay the inoculation was carried out two days after spraying the RIs. In both experiments, LB severity was evaluated after 7 days of the inoculation and, based on these results, the best two RIs were selected for field assays. Four potato cultivars (Yungay, Canchan, UNICA and Serranita) with different levels of LB susceptibility were planted in three areas of Pasco department (average altitude: 2860 m.a.s.l) where LB is endemic. Treatments evaluated were PKplus®, Manvert Biolet®, and propineb, all sprayed alone or alternated; a decision support system (DSS, using commercial systemic and/or propineb); and a control plot with no fungicides. Late blight severity (%) was estimated weekly. The relative area under the disease progress curve (RAUDPC) was calculated according to Forbes et al. (2014); the environmental impact (EI) according to Kovach et al, (1992); and the marginal rate of return (MRR) according to CIMMYT (1998). Yield was estimated in all assays.

Results

Laboratory and greenhouse assays.

In the laboratory assay, PKplus® (mean severity [s] = 8.5%), Manvert Biolet® (s = 15.0%), mancozeb (s = 9.7%) and propineb (s = 10.4%) treatments did not show statistical differences among them ($p > 0.01$) until 15 days after spray in the RIs. In contrast, Manvert Silikon® (s = 100.0%) and Miconic® (s = 99.7%) had LB severity values significantly higher than those of mancozeb and propineb ($p < 0.01$).

In the greenhouse assay, PKplus® (s = 0.5%), mancozeb (s = 0.0%) and propineb (s = 0.0%) treatments did not show statistical differences ($p > 0.01$) in LB severity. Manvert Biolet® (s = 13.8%) was less effective than PKplus® ($p < 0.01$), but it was better than Manvert Silikon® (s = 51.2%) and Miconic® (s = 63.8%) ($p < 0.01$) (Figure 1).

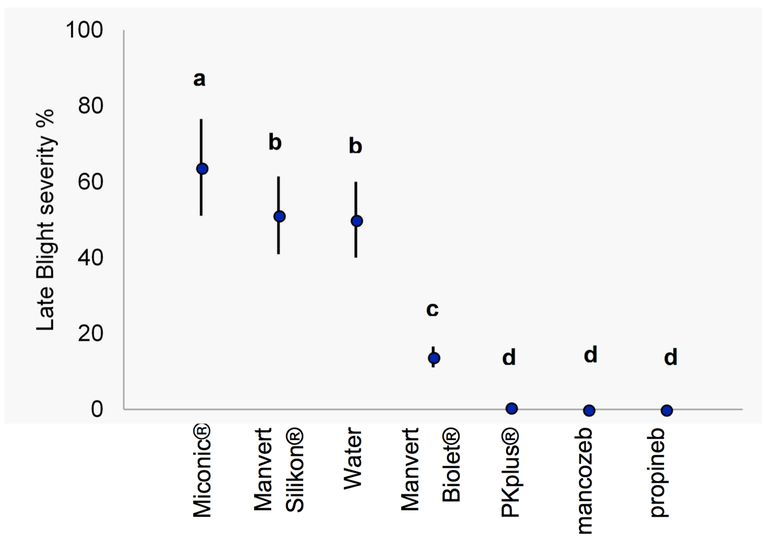

Figure 1. Late blight severity on seven treatments evaluated on whole plants under greenhouse conditions in Lima, Peru.

Field assays

As expected, there was a significant interaction ($p < 0.01$) between cultivars and treatments ($p < 0.01$), pointing out that the effect of treatments depended on the susceptibility levels of the potato cultivars.

Applications of PKplus® and propineb (alone or alternated) and the use of DSS resulted in low LB severity and high yield in the susceptible cultivars Canchan and Yungay. In the moderately resistant cultivar UNICA, most treatments resulted in high yield values, except for alternated applications of PKplus® and Manvert Biolet®. All treatments were effective in the resistant cultivar Serranita (Table 1).

In the susceptible cultivars, the use of DSS presented MRR values higher than 50%, but at the same time the highest EI values (Table 1). In contrast, the lowest EI values were obtained with applications of Manvert Biolet® alone, but this treatment had a lower net benefit than the other treatments (it was *dominated*) and, therefore, MRR could not be estimated.

Treatments with applications of PKplus® and/or propineb (alone or alternated), presented low EI values and MRR values higher than 50% (Table 1). In the moderately resistant cultivar, similar EI values were obtained with use of DSS, PKplus® and propineb (alone or alternated). However, MRR values above 50% were obtained with alternated applications of PKplus® and Manvert Biolet® with propineb, applications of propineb alone and the use of the DSS. EI values in the resistant cultivar were similar for most treatments, except with Manvert Biolet® alone and alternated with PKplus®. MRR values higher than 50% were obtained with applications of propineb and the use of the DSS (Table 1).

Table 1. Resistance inductors evaluated four potato cultivars under field conditions in the highlands of Peru..

Cultivar and Treatment	rAUDPC[a]	Yield[b]	Environmental Impact (EI)[c]	Marginal rate of return (MRR)[d]
Canchan				
PKplus	0.06d^	17.8ab	274.8	97.0
PKplus-Propineb	0.05d	22.5a	331.6	225.3
Manvert Biolet	0.16b	8.3bc	47.5	
Manvert Biolet-Propineb	0.09c	9.1bc	193.5	
PKplus-Manvert Biolet	0.11c	8.9bc	164.7	
Propineb	0.05d	16.8ab	330.2	346.4
DSS[e]	0.01e	18.0ab	481.4	119.5
No fungicide	0.34a	1.8c	0.0	
Yungay				
PKplus	0.04de	16.5ab	271.2	72.1
PKplus-Propineb	0.04de	14.0ab	295.3	102.2
Manvert Biolet	0.11b	6.3bc	45.4	
Manvert Biolet-Propineb	0.06cd	11.8abc	171.1	40.0
PKplus-Manvert Biolet	0.08bc	7.2bc	146.7	
Propineb	0.03e	17.8a	332.8	358.6
DSS	0.01f	20.5a	466.2	143.9
No fungicide	0.29a	2.6c	0.00	
UNICA				
PKplus	0.03c	21.9ab	246.30	
PKplus-Propineb	0.04c	27.8a	253.29	124.2
Manvert Biolet	0.12b	20.2ab	38.29	
Manvert Biolet-Propineb	0.03c	24.6ab	157.69	25.4
PKplus-Manvert Biolet	0.09b	17.4b	143.90	
Propineb	0.03c	28.1a	259.37	267.1
DSS	0.02c	27.0ab	282.43	264.7
No fungicide	0.17a	17.46b	0.000	
Serranita				
PKplus	0.01a	21.8a	152.3	
PKplus-Propineb	0.01a	22.0a	168.6	14.4
Manvert Biolet	0.01a	20.1a	26.9	
Manvert Biolet-Propineb	0.01a	21.6a	112.2	
PKplus-Manvert Biolet	0.01a	19.0a	86.1	
Propineb	0.01a	22.7a	187.8	159.2
DSS	0.01a	23.4a	186.4	184.0
No fungicide	0.02a	17.76a	0.000	

[a] rAUDPC: Relative area under the disease progress curve (adimensional).
[b] Yield (t/ha).
[c] Environmental impact (adimensional) calculated as described by Kovach et al. (1992).
[d] Marginal rate of return (%) calculated as described by CIMMYT (1998).
^ Numbers followed by the same letter are not significantly different within each cultivar (Tuckey's test, α = 0.01).
[e] DSS: Decision support system.

Conclusions

PKplus® and Manvert Biolet® were effective to LB control and showed similar performance than common contact fungicides (mancozeb and propineb) under laboratory and greenhouse conditions. Under field conditions, the most effective and efficient treatments depended on the level of the susceptibility of the potato variety. In susceptible cultivars, the best were PKplus® and propineb alone, PKplus® alternated with propineb and the DSS; in a moderately resistant cultivar, the best were PKplus® and Manvert Biolet® alternated with propineb, and propineb alone; and in a resistant cultivar the best was propineb alone. Since PKplus® have very low environmental impact quotients, these results showed that it is possible to control potato LB in a profitable and environmentally-friendly manner, even in susceptible cultivars during the rainy season under Peruvian conditions.

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